Measurement of excited Xe atoms density in accordance with various barrier ribs in AC-PDP by laser absorption spectroscopy

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Abstract

We have measured the excited Xe atoms density in the $1s_5$ metastable states by laser absorption spectroscopy in accordance with various barrier ribs. In this experiment, the average density of one cell in the panel with stripe barrier rib has been measured to be 1.8×10^{12} cm^{-3}. The panel with close type barrier rib has been measured to be 5.1×10^{12} cm^{-3}.

1. Introduction

Plasma display panels have been well known as advanced display panel. The commercial market is drastically growing every year. But there are several problems as low brightness, luminous efficiency and so on. To improve PDPs luminous efficiency, it is needed to search for optimization of PDP cells design. The surface discharged alternating current plasma display panels utilizes the photoluminescence phenomena of phosphors excited by VUV rays from mixture gas included Xe. The xenon atoms in the $1s_4$ resonance state and the $1s_5$ metastable state generate VUV 147 nm and 173 nm VUV light in Xe plasma. It is found that the intensity of VUV 147 nm emission is proportional to that of the infrared (IR) 828 nm emission, and the VUV 173 nm emission is roughly proportional to that of the IR 823 nm emission. So we have studied the basic parameter excited Xe atoms density in AC-PDP by laser absorption spectroscopy (LAS)[1-2]. In this context, the information on excited Xe atoms density in $1s_4$ and $1s_5$ is one of the major factors in realization high luminous efficiency from AC-PDPs. In this experiment, we used a tunable diode laser to carry out laser absorption spectroscopy of Xe atoms. Figure 1 shows schematics of laser absorption spectroscopy used in this experiment. The Tunable diode laser system consist of current, temperature, and piezoelectric-transducer (PZT) controllers. For making fine-frequency adjustments, ramp modulation signal with 10 Hz generated from function generator apply for the PZT controller. The laser diode's output frequency is swept in 0.022 nm per one voltage by the PZT controller. In this experiment, the scanning laser frequency of interest is less than 20 GHz. For the whole absorption line profile of Voigt broadening in AC-PDP, 1.4 V from function generator in applied to the PZT controller under center wavelength of 823.1nm.

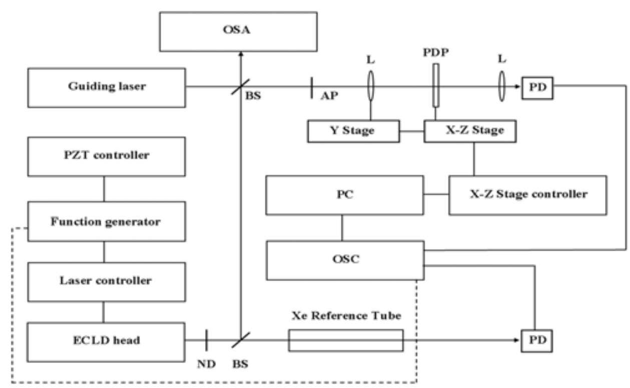


Figure 1. The schematic of laser absorption spectroscopy

The measurement of absorption signal is based on the determination of absorption coefficient k_v from the spectral intensity

$$I_v = I_0 \exp(-k_v x) \quad (1)$$

which is transmitted through an absorption path length x, where I_0 and I_v are the incident IR probe beam intensity and the transmitted IR probe beam intensity, respectively. Using the x with height of each test panel's barrier rib is an absorption path length through a PDP cell in this experiment, where k_v , obtained from $-\frac{1}{x}\ln(\frac{I_v}{I_0}) = k_v$, is the absorption coefficient per unit length over the scanning frequency. When the IR probe beam with I_v is incident on a PDP cell, it occurs absorption from the $1s_5$ metastable state and the $1s_4$ resonance state. The level N_1 of excited Xe density [1] expressed as

$$N_1 = \frac{8\pi}{\lambda^2}\frac{g_1}{g_2}\frac{1}{A_{21}}\int_{-\infty}^{+\infty} k_v dv \qquad (2)$$

where λ is wavelength when is occurring the maximum absorption, g_1 and g_2 which are the statistical weights of the lower and upper levels of the transition[3]. A_{21} is probability per second of a spontaneous jump from upper level to the lower level. The $\int_{-\infty}^{+\infty} k_v dv$ is integral value of the whole absorption profile with respect to tuning frequency from experimental measurement. Hence the unit of N_1 in Eq. (2) will be in cm^{-3}. since λ is in unit of cm.

The absorption coefficient k_v in Eq. (2) shows pressure broadening voigt profile over the scanning frequency range.

Figure 3 shows pressure broadening of Voigt absorption line profile 823.1 nm in center wavelength for excited Xe atoms in the metastable($1s_5$). This pressure broadening line width is measured to be 9 GHz in the $1s_5$ metastable states.

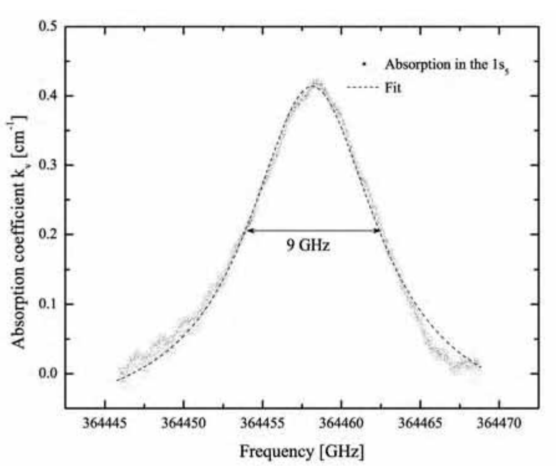
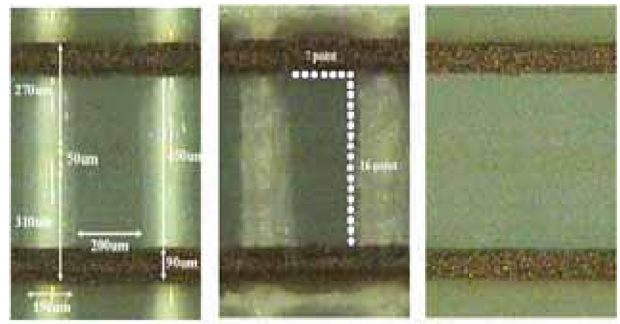


Figure 3. Voigt absorption line profile in the $1s_5$ metastable state.



(a) Stripe type barrier rib (b) Closed type barrier rib (c) Without barrier rib

Figure 4. The cell dimension and scanning points.

Figure 4 shows three kind of rear panel with different barrier ribs. The first one is stripe type barrier rib and its height is 140 um. Second one is closed type barrier rib with 220 um height. And third one is just space of 140 um, as a role of barrier rib, in height is located. And the discharge space between front and rear panel is filled by mixture gas of Ne-Xe(7%) with its pressure of 350 Torr. The sustaining electrode located on the outer edge of transparent electrodes is made of silver paste and its width is held at 90 um. Also the sustaining electrodes that are covered with dielectric layers of 30 um in thickness are parallel to each other in front glass. To transmit laser beam, rear glass has not been used addressing electrodes and phosphor.

The MgO protective layer is deposited on the dielectric layer by the electron beam evaporation method with 0.5 um in thickness. The sustaining gap between the two transparent sustaining electrodes, which is made of indium tin oxide (ITO), is kept at range of 50 um and its width is 300 um.

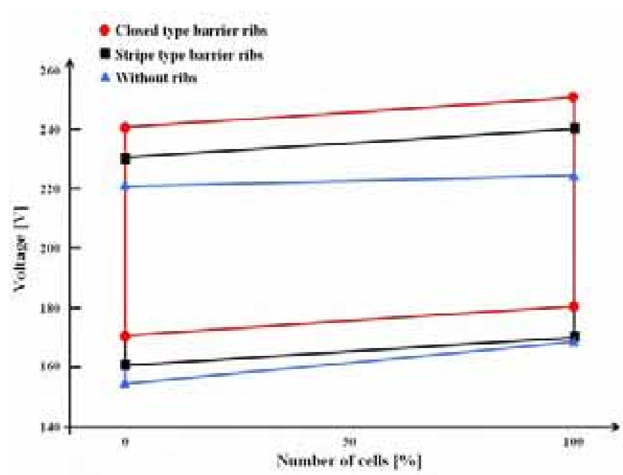


Figure 5. Static margin of each panel

And the PDP cell has been operated by square pulse of the driving frequency 35 kHz with the duty ratio of 25%. After breakdown, the sustaining voltage is maintained at margin of each panel. Figure 5 shows that static margin increased about 10V in accordance with type of barrier ribs. Figure 4-(b) shows schematics of the unit discharge cell which has been scanned by laser IR probe beam with 17.3 um all discharge regions (2-dimensional). The spatial resolution of the measurements is 30 um. The absorption signal has been measured by time-averaged value from the intensity which is transmitted through discharge space in PDP cell.

2. Results

Figure 6 is the distribution of excited Xe atoms density in the $1s_5$ metasbable states without barrier rib. The average density is 5.3 x 10^{12} cm^{-3}. And the excited atom spread out evenly. Figure 7 shows the excited Xe density with stripe type barrier rib. The average density for this case has been measured to be 1.8 x 10^{12} cm^{-3}. And the density is highest at the region of about 150 um away from bus electrode. And it is noted that the excited Xe locally crowded. Figure 8 shows the excited Xe atoms density with closed type barrier rib. The average density has been measured to be 5.1 x 10^{12} cm^{-3}. And the distribution of excited Xe is similar to figure 7.

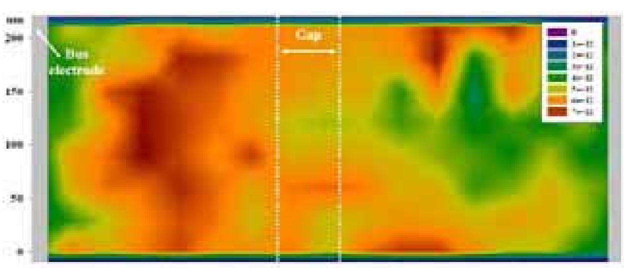


Figure 6. Xe* density in $1s_5$ without rib

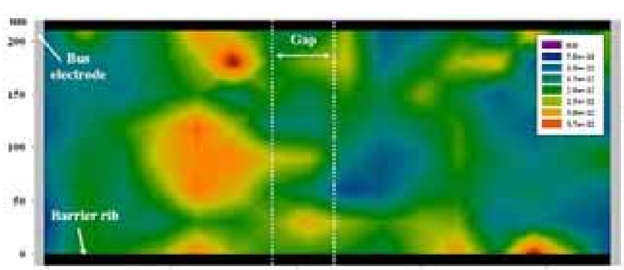


Figure 7. Xe* density in $1s_5$ with stripe type rib

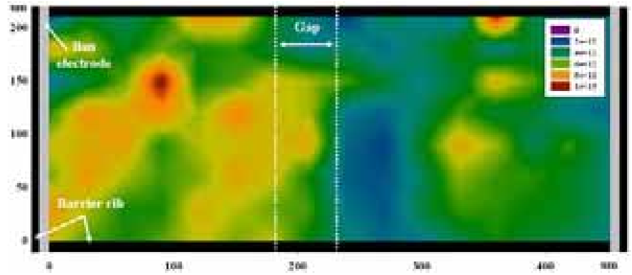


Figure 8. Xe* density in $1s_5$ with closed type rib

In the Figure 9, we can know that the excited Xe atoms density in $1s_5$ with closed type barrier rib is about three times higher than the stripe type barrier rib. Figures 10 and 11 show that IR discharge emission intensity of closed type barrier ribs are higher than stripe type barrier ribs. It is noted that excited Xe atom's density and IR emission have a broader distribution at closed type barrier ribs than stripe type barrier ribs as shown in these figures.

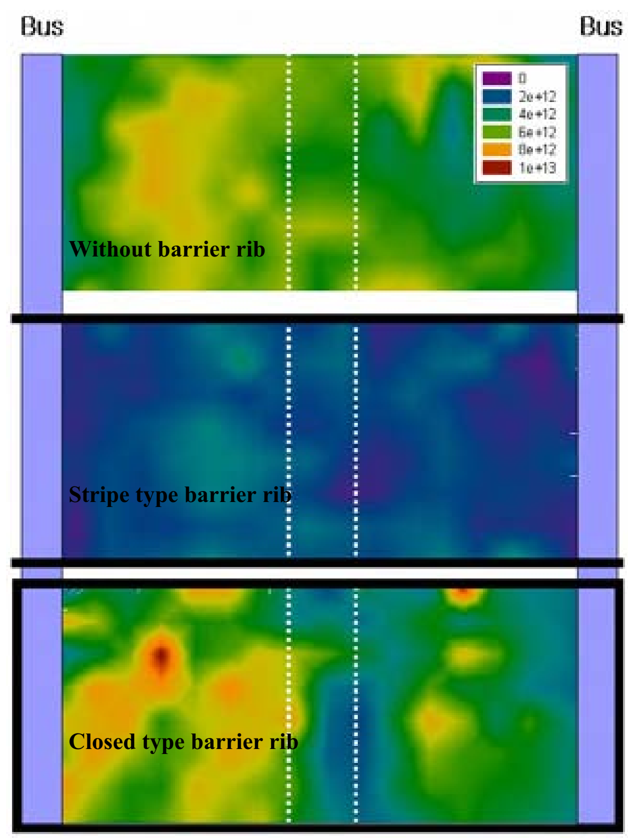


Figure 9. Comparison of Xe* density in $1s_5$ in the same scale

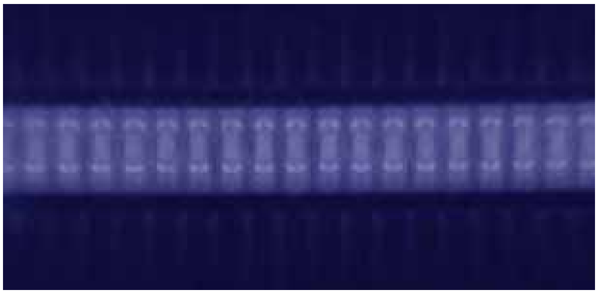


Figure 10. IR image of stripe type barrier ribs.

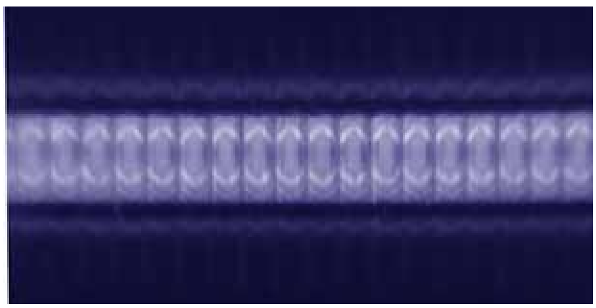


Figure 11. IR image of closed type barrier ribs.

3. Conclusion

We have studied the two dimensional distribution of the excited Xe atoms density in $1s_5$ metastable states in accordance with various barrier ribs. In the closed type barrier ribs, excited Xe atoms have distributed widely than stripe type barrier ribs. It is also shown that IR discharge emission intensity is widely in the closed type barrier ribs than stripe type barrier ribs.

It is found that the excited Xe atoms density of closed type barrier ribs is higher about three times than stripe barrier ribs. The average density measured to be 5.1 x 10^{12} cm^{-3} in AC-PDPs with closed type barrier ribs.

4. References

[1] K. Tachibana, S. Feng, and T. Sakai, "spatiotemporal behaviors of excited Xe atoms in unit discharge cell of ac type plasma display panel studied by laser spectroscopic microscopy" J. Appl. Phys. 88, No. 9, pp. 4967-4974, 2000.

[2] K. Tachibana, N. Kosugi and T. Sakai, "Spatio-temporal measurement of excited Xe($1s_4$) atoms in a discharge cell of a plasma display panel by laser spectroscopic microscopy", Appl. Phys. Lett., Vol. 65, No. 8, pp. 935-937, 1994.

[3] K. C. Harvey and C. J. Myatt, "External-cavity diode laser using a grazing-incidence diffraction grating", Optics letters, vol. 16, p. 910-912, 1991.